IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT: LEE, Kujin; KWEON, In So; KIM, Howon; KIM, Junsik

SERIAL NO.:

FILED: Herewith

TITLE: METHOD AND APPARATUS FOR OMNI-DIRECTIONAL IMAGE AND 3-DIMENSIONAL DATA ACQUISITION WITH DATA ANNOTATION AND DYNAMIC RANGE EXTENSION METHOD

PRELIMINARY AMENDMENT

Commissioner of Patents
and Trademarks
Washington, D.C. 20231

Sir:

In conjunction with the filing of the present application, and prior to an initial Official Action on this matter, please amend the above-identified application as follows:

<u>IN THE SPECIFICATION</u>

In Paragraph [0005], please substitute the paragraph as follows:

Currently, the prior-art methods to capture omni-directional images may be categorized as below:

(a) a method to cover about hemispheric viewing angle using non-planer mirror and a camera;

(b) a method to cover wider viewing angle using multiple planer mirror and multiple cameras;

(c)a method to generate a panoramic image by connecting a plurality of images which are obtained as a camera rotates;

(d) a method to produce a single image as by connecting a plurality of images which are obtained as a line-scan camera rotates (http://www.e-pan.com/index.html);

(e) a method to cover wider viewing angle by a plurality of imaged which are obtained as a plurality of cameras each of which covers different viewing angle(for example, US patent 5,023,725); and

(f) a method to cover about hemispheric viewing angle using a camera with fisheye lens (for example, US patent 5,185,667).

In Paragraph [0026], please substitute the paragraph as follows:

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate exemplary embodiment(s) of the invention and together with the description serve to explain the principle of the invention.

In Paragraph [0103], please substitute the paragraph as follows:

FIG. 15 is a flow diagram illustrating a process of acquiring 3-dimensional depth data using epipolar geometry by the omni-directional 3-dimension image data acquisition apparatus according to the invention. Namely, FIG. 15 shows steps of image data acquisition to 3-dimensional data extraction using the spherical coordinate arrangement and applying epipolar geometry. This method comprising the steps of:

assuming a spherical coordinate where the center of spherical coordinate is set to the projection center of the camera 11 and axis of the spherical coordinate and optical axis of the camera 11 is collinearS100;

finding a mapping table or function between points on the spherical coordinate and points on the image plane of the camera 11 by either empirical or mathematical calibration S200;

acquiring two images of same scene with small displacement between two 2D images acquisition locations S300;

mapping those 2D images to the surfaces of two spheres (or to some data structure to express spheres) using the mapping table or function S400;

rotating said spherical coordinates of those spheres to make their axes and connecting line between optical projection centers of paired cameras 11 become collinear S500;

applying epipolar geometry to correlate points between said two images S600;

determing spatial location of correlated points by triangulation S700; and

possibly repeating the steps from S300 to S700 to make more images to possibly acquire.

IN THE CLAIMS

In Claim 1, the claim as follows:

1. (Amended) An omni-directional image and 3-Dimensional data acquisition apparatus, comprising:

a multi-camera module constructed in a manner [that] comprising a plurality of cameras that are symmetrically arranged with a specific point in a plane, each of the cameras taking charge of each of divided angles such that the camera module can take an omni-directional continuous panoramic photograph of surrounding objects with the specific point;

first frame grabbers each of which is electrically connected to each of the cameras of the multi-camera module, to grab photographed images by frames;

an exposure calculator electrically connected to the first frame grabbers, to calculate exposure of each camera, based on the grabbed images by frames;

an exposure signal generator electrically connected to each camera, to transmit information about the exposure as a signal on the basis of the exposure calculated by the exposure calculator;

storage means electrically connected to the each first frame grabber, to store images photographed by the cameras according to photographing location and photographing time;

a GPS sensor to sense the photographing location and photographing time;

an annotation entering unit electrically connected to the GPS sensor to calculate location and time corresponding to each frame based on sensed data of the GPS sensor, the annotation entering unit being electrically connected to the storage means to enter the calculated location and time in each frame as annotation; and

a trigger signal generator electrically connected the storage means, the exposure signal generator, the annotation entering unit, the trigger signal generator selectively transmits a trigger signal to the exposure signal generator or the annotation entering unit in order that the cameras start to photograph the objects according to the trigger signal; and wherein the multi-camera module are vertically stacked and formed in at least two layers in the direction of height.

In Claim 3, please substitute the claim as follows:

3. (Amended) The apparatus as claimed in claim 1, wherein the storage means is one of digital storage devices comprised of a hard disk, compact disk, magnetic tape and memory.

In Claim 6, please substitute the claim as follows:

6. (Amended) The apparatus as claimed in claim 1, wherein the multi-camera module further comprises at least one camera placed at the top thereof so that the camera can photograph an object upward.

In Claim 10, please substitute the claim as follows:

10. (Amended) A method for extending dynamic range of images, comprising the steps of:

acquiring for multi images of an object, the multi images being photographed by the cameras which have different exposure amount each other, wherein the multi camera module comprising a plurality of cameras which are symmetrically arranged at a specific point in a plane, and which take charge of each allocating viewing angle calculated by 360° divided by the number of the cameras;

selectively extracting for regions in the multi images, wherein the regions have constant exposure amount; and

acquiring for images of dynamic range extension, which are generated by composing the extracting regions.

In Claim 11, please substitute the claim as follows:

11. (Amended) An omni-directional image and 3-Dimensional data acquisition apparatus, comprising:

a multi-camera module constructed in a manner comprised of a plurality of cameras that are symmetrically arranged with a specific point in a plane, each of the cameras taking charge of each of divided angles such that the camera module can take an omni-directional continuous panoramic photograph of surrounding objects with the specific point;

an elevator for elevating the multi-camera module vertically;

first frame grabbers each of which is electrically connected to each of the cameras of the multi-camera module, to grab photographed images by frames;

an exposure calculator electrically connected to the first frame grabbers, to calculate exposure of each camera, based on the grabbed images by frames;

an exposure signal generator electrically connected to each camera, to transmit information about the exposure as a signal on the basis of the exposure calculated by the exposure calculator;

storage means electrically connected to the each first frame grabber, to store images photographed by the cameras according to photographing location and photographing time;

a GPS sensor to sense the photographing location and photographing time;

an annotation entering unit electrically connected to the GPS sensor to calculate location and time corresponding to each frame based on sensed data of the GPS sensor, the annotation entering unit being electrically connected to the storage means to enter the calculated location and time in each frame as annotation; and

a trigger signal generator electrically connected the storage means, the exposure signal generator, the annotation entering unit, the trigger signal generator selectively transmits a trigger signal to the exposure signal generator or the annotation entering unit in order that the cameras start to photograph the objects according to the trigger signal.

IN THE ABSTRACT

On page 31, please substitute the paragraph as follows:

A method and apparatus for omni-directional image and 3-dimensional data acquisition with data annotation and dynamic rage extension method is capable of omni-directionally photographing, acquiring 3-dimensional images photographed by cameras having each different exposure amount in connection with the direction of height of an object, extending dynamic range, and generating an geographical information by entering an annotation such as photographing location and time into the photographed images, which can be connected with other geographical information system database. The apparatus includes one or more multi camera module(s) which are stacked and formed multi layers in the direction of height for acquiring 3-dimensional images and extending dynamic range of the 3-dimensional images, wherein each multi camera module includes a plurality of cameras symmetrically arranged with a specific point in a plane.

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REMARKS ON PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

In this preliminary amendment, please consider the following remarks in conjunction with the amendments to the above-identified application as follows:

REMARKS

The present Preliminary Amendment has been entered for the purpose of placing the application into a more proper U.S. format. In particular, certain grammatical and idiomatic inconsistencies have been corrected by amendment to the specification, and the application is corrected for certain typographical errors found in the originally submitted application. No new matter has been added by these amendments.

The claims and Abstract have been amended so as to conform with U.S. requirements.

Applicant respectfully requests that the present Amendment be entered prior to an initial Official Action on the present application.

Respectfully submitted,

Feb 8, 2002
Date

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VERSION WITH MARKINGS TO SHOW CHANGES in the PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

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IN THE SPECIFICATION

In Paragraph [0005], the paragraph has been amended as follows:

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(d) a method to produce a single image as by connecting a plurality of images which are obtained as a line-scan camera rotates (http://www.e-pan.com/index.html);

(e) a method to cover wider viewing angle by a plurality of imaged which are obtained as a plurality of cameras each of which covers different viewing angle(for example, US patent 5,023,725); and

(f) a method to cover about hemispheric viewing angle using a camera with fisheye lens (for example, US patent 5,185,667).

In Paragraph [0026], the paragraph has been amended as follows:

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate exemplary embodiment(s) of the invention and together with the description serve to explain the principle of the invention. [In the drawings;]

In Paragraph [0103], the paragraph has been amended as follows:

FIG. 15 is a flow diagram illustrating a process of acquiring 3-dimensional depth data using epipolar geometry by the omni-directional 3-dimension image data acquisition apparatus according to the invention. Namely, FIG. 15 shows steps of image data acquisition to 3-dimensional data extraction using the spherical coordinate arrangement and applying epipolar geometry. This method comprising the steps of:

assuming a spherical coordinate [is assumed] where the center of spherical coordinate is set to the projection center of the camera 11 and axis of the spherical coordinate and optical axis of the camera 11 is collinearS100[.];

[Mapping] finding a mapping table or function between points on the spherical coordinate and points on the image plane of the camera 11 [is found] by either empirical or mathematical calibration S200[.];

[Acquire] acquiring two images of same scene with small displacement between two 2D images acquisition locations S300[.];

[Map] mapping those 2D images to the surfaces of two spheres (or to some data structure to express spheres) using the mapping table or function S400[.];

[Rotate the] rotating said spherical coordinates of those spheres to make their axes and connecting line between optical projection centers of paired cameras 11 become collinear S500[.];

[Apply] applying epipolar geometry to correlate points between said two images S600[.];

[Determine] determing spatial location of correlated points by triangulation S700[.]; and

[Further, the repeat of] possibly repeating the steps from S300 to S700 [makes] to make more images to possibly acquire.

IN THE CLAIMS

In Claim 1, the claim has been amended as follows:

1. (Amended) An omni-directional image and 3-Dimensional data acquisition apparatus, comprising:

a multi-camera module constructed in a manner [that] comprising a plurality of cameras that are symmetrically arranged with a specific point in a plane, each of the cameras taking charge of each of divided angles such that the camera module can take an omni-directional continuous panoramic photograph of surrounding objects with the specific point;

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an exposure calculator electrically connected to the first frame grabbers, to calculate exposure of each camera, based on the grabbed images by frames;

an exposure signal generator electrically connected to each camera, to transmit information about the exposure as a signal on the basis of the exposure calculated by the exposure calculator;

storage means electrically connected to the each first frame grabber, to store images photographed by the cameras according to photographing location and photographing time;

a GPS sensor to sense the photographing location and photographing time;

an annotation entering unit electrically connected to the GPS sensor to calculate location and time corresponding to each frame based on sensed data of the GPS sensor, the annotation entering unit being electrically connected to the storage means to enter the calculated location and time in each frame as annotation; and

a trigger signal generator electrically connected the storage means, the exposure signal generator, the annotation entering unit, the trigger signal generator selectively transmits a trigger signal to the exposure signal generator or the annotation entering unit in order that the cameras start to photograph the objects according to the trigger signal; and [

]wherein the multi-camera module are vertically stacked and formed in at least two layers in the direction of height.

In Claim 3, the claim has been amended as follows:

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In Claim 10, the claim has been amended as follows:

10. (Amended) A method for extending dynamic range of images, comprising the steps of:

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selectively extracting for regions in the multi images, wherein the regions have constant exposure amount; and

acquiring for images of dynamic range extension, which are generated by composing the extracting regions.

In Claim 11, the claim has been amended as follows:

11. (Amended) An omni-directional image and 3-Dimensional data acquisition apparatus, comprising:

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an annotation entering unit electrically connected to the GPS sensor to calculate location and time corresponding to each frame based on sensed data of the GPS sensor, the annotation entering unit being electrically connected to the storage means to enter the calculated location and time in each frame as annotation; and

a trigger signal generator electrically connected the storage means, the exposure signal generator, the annotation entering unit, the trigger signal generator selectively transmits a trigger signal to the exposure signal generator or the annotation entering unit in order that the cameras start to photograph the objects according to the trigger signal.

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